IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: ASUMALAHTI et al.

Docket: 5848.161USW1

Title: POLYMER COMPOSITION FOR PIPES

CERTIFICATE UNDER 37 C.F.R. 1.10:
"Express Mail" mailing label number: EL658341883US
Date of Deposit: January 2, 2001

I hereby certify that this paper or fee is being deposited with the U.S. Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10 on the date indicated above and is addressed to Assistant Commissioner for Patents, Washington, D.C. 20231.

By _____
Name Brant Miles

REQUEST FOR FILING A CONTINUATION OF AN INTERNATIONAL APPLICATION

Box Patent Application
Assistant Commissioner for Patents
Washington, DC 20231

Dear Sir:

This is a request for filing a continuation application under 37 C.F.R. § 1.53(b) and 35 U.S.C. § 111(a), of pending prior international application Number PCT/ SE99/01195, filed on July 1, 1999, entitled POLYMER COMPOSITION FOR PIPES, which designated the United States.

1. ☒ Enclosed is the application as follows: 13 pages of specification, 15 claims, 1 pages of abstract, 0 sheet(s) of drawing(s).

CLAIMS AS FILED

NUMBER FILED		NUMBER EXTRA		RATE	FEE
TOTAL CLAIMS: 15	-20	0	x	$0.00	0.00
INDEPENDENT CLAIMS 2	-3	0	x	$0.00	0.00
				BASIC FILING FEE:	$710.00
				TOTAL FILING FEE:	710.00

2. ☐ Small entity status is claimed pursuant to 37 CFR 1.27.

3. ☒ A check in the amount of $710.00 is enclosed.

4. ☒ The Commissioner is hereby authorized to charge any fees which may be required under 37 C.F.R. § 1.16 and § 1.17, or credit any overpayment to Deposit Account No. 13-2725.

5. ☒ Amend the specification by inserting before the first line the sentence: "This application is a continuation of international application number PCT/ SE99/01195, filed July 1, 1999, pending."

☒ A signed declaration under 37 C.F.R. § 1.63 is enclosed.

7. ☐ A set of formal drawings (sheets) is enclosed.

8. ☒ An Assignment of the invention to Borealis Technology Oy, Recordation Form Cover Sheet, and fee of $40.00 is enclosed.

9. ☒ Priority of foreign application number 9802409-4, filed on July 6, 1998 in Sweden, is claimed under 35 U.S.C. 119(a)-(d).

☒ The certified copy is enclosed.

10. ☒ A preliminary amendment is enclosed.

11. ☒ Also Enclosed: Form PCT/ISA/210; Form PCT/IB/306; Notice of Change of Address of Inventor; Form PCT/IPEA/409; Form PCT/IB/308; Form PCT/IPEA/402; Form PCT/RO/101

12. ☒ Return postcard

Address all future correspondence to:

John J. Gresens
MERCHANT & GOULD P.C.
P.O. Box 2903
Minneapolis, MN 55402-0903

Respectfully submitted,
MERCHANT & GOULD P.C.
P.O. Box 2903
Minneapolis, Minnesota 55402-0903
(612) 332-5300

Dated: January 2, 2001

By _____
John J. Gresens
Reg. No. 33,112

JJG/kas

S/N unknown PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

A/#4 ASellmon 03/07/01

Applicant:	ASUMALAHTI et al.	Serial No.:	unknown
Filed:	concurrent herewith	Docket No.:	5848.161USW1
Title:	POLYMER COMPOSITION FOR PIPES		

CERTIFICATE UNDER 37 CFR 1.10
'Express Mail' mailing label number: EL658341883US
Date of Deposit: January 2, 2001
I hereby certify that this correspondence is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C . 20231.

By: Brant Miles
Name: Brant Miles

PRELIMINARY AMENDMENT

Box PCT
Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Sir:

In connection with the above-identified application filed herewith, please enter the following preliminary amendments:

IN THE ABSTRACT

Insert the attached Abstract page into the application as the last page thereof.

IN THE SPECIFICATION

N.E A courtesy copy of the present specification is enclosed herewith. However, the World Intellectual Property Office (WIPO) copy should be relied upon if it is already in the U.S. Patent Office.

IN THE CLAIMS

Please amend claims 4, 5, 6, 10 and 14 as follows:

A1 4. (amended) A multimodal polymer composition as claimed in claim 1, wherein the amount of comonomer is 0.4-3.5 mol% of the multimodal polymer.

A1

5. (amended) A multimodal polymer composition according to claim 1, having a weight ratio of the LMW fraction to the HMW fraction of (43-51):(57-49).

6. (amended) A multimodal polymer composition as claimed in claim 1, wherein the multimodal polymer has an MFR_5 of 0.3-1.0 g/10 min.

2

10. (amended) A multimodal polymer composition as claimed in claim 7, wherein polymerisation procatalyst and cocatalyst are added to the first polymerisation reactor only.

3

14. (amended) A pipe as claimed in claim 12, wherein the pipe has a rapid crack propagation (RCP) S4-value of -1°C or lower.

REMARKS

The above preliminary amendment is made to remove multiple dependencies from claims 4, 5, 6, 10 and 14.

A new abstract page is supplied to conform to that appearing on the publication page of the WIPO application, but the new Abstract is typed on a separate page as required by U.S. practice.

Applicants respectfully request that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of record, John J. Gresens (Reg. No. 33,112), at 612.371.5265.

Respectfully submitted,

MERCHANT & GOULD P.C.
P.O. Box 2903
Minneapolis, Minnesota 55402-0903
(612) 332-5300

Dated: January 2, 2001

By _____
John J. Gresens
Reg. No. 33,112

JJG/kas

CLAIMS

1. A multimodal polyethylene composition for pipes, which multimodal polyethylene has a density of 0.930-0.965 g/cm^3 and an MFR_5 of 0.2-1.2 g/10 min, c h a r a c t e r i s e d in that the multimodal polyethylene has an M_n of 8000-15000, an M_w of 180-330 x 10^3, and an M_w/M_n of 20-35, said multimodal polyethylene comprising a low molecular weight (LMW) ethylene homopolymer fraction and a high molecular weight (HMW) ethylene copolymer fraction, said HMW fraction having a lower molecular weight limit of 3500, and a weight ratio of the LMW fraction to the HMW fraction of (35-55):(65-45).

2. A multimodal polymer composition as claimed in claim 1, wherein the multimodal polymer is a bimodal polyethylene produced by (co)polymerisation in at least two steps.

3. A multimodal polymer composition as claimed in claim 1, wherein the ethylene copolymer of the HMW fraction is a copolymer of ethylene and a comonomer selected from the group consisting of 1-butene, 1-hexene, 4-methyl-1-pentene, and 1-octene.

4. A multimodal polymer composition as claimed in --claim 1-- (any one of claims 1-3), wherein the amount of comonomer is 0.4-3.5 mol% of the multimodal polymer.

5. A multimodal polymer composition according to --claim 1-- (any of claims 1-4), having a weight ratio of the LMW fraction to the HMW fraction of (43-51):(57-49).

6. A multimodal polymer composition as claimed in --claim 1-- (any one of claims 1-5) wherein the multimodal polymer has an MFR_5 of 0.3-1.0 g/10 min.

7. A multimodal polymer composition as claimed in claim 1, wherein the polymer is obtained by slurry polymerisation in a loop reactor of a LMW ethylene homo-

polymer fraction, followed by gas-phase polymerisation of a HMW ethylene copolymer fraction.

8. A multimodal polymer composition as claimed in claim 7, wherein the slurry polymerisation is preceded by a prepolymerisation step.

9. A multimodal polymer composition as claimed in claim 8, wherein the polymer is obtained by prepolymerisation in a loop reactor, followed by slurry polymerisation in a loop reactor of a LMW ethylene homopolymer fraction, and gas-phase polymerisation of a HMW ethylene copolymer fraction.

10. A multimodal polymer composition as claimed in [--claim 7--] any one of claims 7-9 wherein polymerisation procatalyst and cocatalyst are added to the first polymerisation reactor only.

11. A multimodal polymer composition as claimed in claim 10, wherein the polymerisation catalyst is a Ziegler-Natta type catalyst.

12. A pipe c h a r a c t e r i s e d in that it is a pressure pipe comprising the multimodal polymer composition according to any one of the preceding claims, which pipe withstands a pressure of 8.0 MPa gauge during 50 years at 20°C (MRS8.0).

13. A pipe as claimed in claim 12, wherein the pipe is a pressure pipe withstanding a pressure of 10 MPa gauge during 50 years at 20°C (MRS10.0).

14. A pipe as claimed in [claim 12 or 13,--claim 12--] wherein the pipe has a rapid crack propagation (RCP) S4-value of -1°C or lower.

15. A pipe as claimed in claim 14, wherein the pipe has a rapid crack propagation (RCP) S4-value of -7°C or lower.

POLYMER COMPOSITION FOR PIPES

Field of the invention

The present invention relates to a multimodal polymer composition for pipes and a pipe prepared thereof.

Background of the invention

Nowadays, pipes of polymer material are frequently used for various purposes, such as fluid transport, i.e. transport of liquid or gas, e.g. water or natural gas, during which the fluid can be pressurised. Moreover, the transported fluid may have varying temperatures, usually within the temperature range from about 0°C to about 50°C. Such pressure pipes are preferably made of polyolefin plastic, usually unimodal ethylene plastic such as medium density polyethylene (MDPE; density: 0.930-0.942 g/cm^3) and high density polyethylene (HDPE; density: 0.945--0.965 g/cm^3). By the expression "pressure pipe" herein is meant a pipe which, when used, is subjected to a positive pressure, i.e. the pressure inside the pipe is higher than the pressure outside the pipe.

Polymer pipes are generally manufactured by extrusion, or, to a smaller extent, by injection moulding. A conventional plant for extrusion of polymer pipes comprises an extruder, a nozzle, a calibrating device, cooling equipment, a pulling device, and a device for cutting or for coiling-up the pipe.

The properties of such conventional polymer pipes are sufficient for many purposes, although enhanced properties may be desired, for instance in applications requiring high pressure resistance, i.e. pipes that are subjected to an internal fluid pressure for a long and/or short period of time. As examples of properties which it is desirable to improve may be mentioned the processability, the impact strength, the modulus of elasticity, the rapid crack propagation resistance, the slow crack growth resistance, and the design stress rating of the pipe.

Summary of the invention

It has now been discovered that a superior pressure pipe may be obtained by preparing it from a specific, well defined type of multimodal polyethylene. More particularly, the multimodal polyethylene should have a medium to high density, have a broad molecular weight distribution, a carefully selected ratio between its low molecular weight fraction and high molecular weight fraction, and include a comonomer in its high molecular weight fraction only.

Thus, the present invention provides a multimodal polyethylene composition for pipes, which multimodal polyethylene has a density of 0.930-0.965 g/cm^3 and an MFR_5 of 0.2-1.2 g/10 min, characterised in that the multimodal polyethylene has an M_n of 8000-15000, an M_w of 180-330 x 10^3, and an M_w/M_n of 20-35, said multimodal polyethylene comprising a low molecular weight (LMW) ethylene homopolymer fraction and a high molecular weight (HMW) ethylene copolymer fraction, said HMW fraction having a lower molecular weight limit of 3500, and a weight ratio of the LMW fraction to the HMW fraction of (35-55):(65-45).

Other distinguishing features and advantages of the invention will appear from the following specification and the appended claims.

Detailed description of the invention

As stated above, the pressure pipe composition of the present invention is made from a multimodal polyethylene. This is in contrast to prior art polyethylene pipes which usually are made of unimodal polyethylene.

The "modality" of a polymer refers to the form of its molecular weight distribution curve, i.e. the appearance of the graph of the polymer weight fraction as function of its molecular weight. If the polymer is produced in a sequential step process, utilizing reactors coupled in series and using different conditions in each reactor, the different fractions produced in the different reactors

will each have their own molecular weight distribution. When the molecular weight distribution curves from these fractions are superimposed into the molecular weight distribution curve for the total resulting polymer product, that curve will show two or more maxima or at least be distinctly broadened in comparison with the curves for the individual fractions. Such a polymer product, produced in two or more serial steps, is called bimodal or multimodal depending on the number of steps. In the following all polymers thus produced in two or more sequential steps are called "multimodal". It is to be noted here that also the chemical compositions of the different fractions may be different. Thus one or more fractions may consist of an ethylene copolymer, while one or more others may consist of ethylene homopolymer.

By properly selecting the different polymer fractions and the proportions thereof in the multimodal polyethylene a pipe with inter alia enhanced processability can be obtained.

The pressure pipe composition of the present invention is a multimodal polyethylene, preferably a bimodal polyethylene. The multimodal polyethylene comprises a low molecular weight (LMW) ethylene homopolymer fraction and a high molecular weight (HMW) ethylene copolymer fraction. Depending on whether the multimodal polyethylene is bimodal or has a higher modality the LMW and HMW fractions may comprise only one fraction each or include sub-fractions, i.e. the LMW may comprise two or more LMW sub-fractions and similarly the HMW fraction may comprise two or more HMW sub-fractions. It is a characterising feature of the present invention that the LMW fraction is an ethylene homopolymer and that the HMW fraction is an ethylene copolymer, i.e. it is only the HMW fraction that includes a comonomer. As a matter of definition, the expression "ethylene homopolymer" used herein relates to an ethylene polymer that consists substantially, i.e. to at least 97% by weight, preferably at least 99% by

weight, more preferably at least 99.5% by weight, and most preferably at least 99.8% by weight of ethylene and thus is an HD ethylene polymer which preferably only includes ethylene monomer units. Moreover, the lower limit of the molecular weight range of the HMW fraction is 3 500, preferably 4000. This means that almost all ethylene copolymer molecules in the multimodal polyethylene pipe composition of the invention have a molecular weight of at least 3500, preferably at least 4000. The reason for this is that the presence of comonomer in the LMW fraction gives a pressure pipe with poor strength.

In the present invention it is further important that the proportions of the LMW and HMW fractions (also known as the "split" between the fractions) are selected properly. More particularly, the weight ratio of the LMW fraction to the HMW fraction should lie in the range (35-55):(65-45), preferably (43-51):(57-49), most preferably (43-48):(57-52). It is important that the split lies within these ranges, because if the proportion of the HMW fraction becomes to great it results in too low strength values and if it is too low it results in an unacceptable formation of gels.

The molecular weight distribution, as defined by the ratio of the weight average molecular weight (M_w) to the number average molecular weight (M_n), i.e. M_w/M_n, of the multimodal polyethylene is rather broad at the present invention and has a value of 20-35, preferably 22-30. The reason for this is to obtain a pressure pipe with a desired combination of good processability and good strength. Further, the number average molecular weight, M_n, has a value of 8 000-15 000, preferably 9 000-14 000, while the weight average molecular weight, M_w, has a value of 180-330 x 10^3, preferably 200-320 x 10^3 (180-260 x 10^3, preferably 200-250 x 10^3, for an MD pipe material and 250-330 x 10^3, preferably 280-320 x 10^3, for an HD pipe material).

The melt flow rate (MFR), which is equivalent to the term "melt index" previously used, is another important property of the multimodal polyethylene for pipes according to the invention. The MFR is determined according to ISO 1133 and is indicated in g/10 min. The MFR is an indication of the flowability, and hence the processability, of the polymer. The higher the melt flow rate, the lower the viscosity of the polymer. The MFR is determined at different loadings such as 2.1 kg ($MFR_{2.1}$; ISO 1133, condition D) or 5 kg (MFR_5; ISO 1133, condition T). At the present invention the multimodal polyethylene has an MFR_5 of 0.2-1.2 g/10 min, preferably 0.3-1.0 g/10 min.

Another characterising feature of the present invention is the density of the multimodal polyethylene. For reasons of strength the density lies in the medium to high density range, more particularly in the range 0.930--0.965 g/cm^3. Preferably, lower densities of 0.937--0.942 g/cm^3 are used for smaller diameter MD pressure pipes, while higher densities of 0.943-0.955 g/cm^3 are used for larger diameter HD pressure pipes. The pressure pipes of medium density multimodal polyethylene are somewhat more flexible than pressure pipes of high density multimodal polyethylene and may therefore more easily be coiled into a roll. On the other hand it is possible to obtain pressure pipes of a higher design stress rating with high density multimodal polyethylene than with medium density multimodal polyethylene.

It should be noted that the multimodal polymer composition of the present invention is characterised, not by any single one of the above defined features, but by the combination of all the features defined in claim 1. By this unique combination of features it is possible to obtain pressure pipes of superior performance, particularly with regard to processability, rapid crack propagation (RCP) resistance, design stress rating, impact strength, and slow crack growth resistance.

The processability of a pipe (or rather the polymer thereof) may be determined in terms of the number of screw revolutions per minute (rpm) of an extruder for a predetermined output of pipe in kg/h, but also the surface appearance of the pipe is then important.

The rapid crack propagation (RCP) resistance of a pipe may be determined according to a method called the S4 test (Small Scale Steady State), which has been developed at Imperial College, London, and which is decribed in ISO DIS 13477. According to the RCP-S4 test a pipe is tested, which has an axial length not below 7 pipe diameters. The outer diameter of the pipe is about 110 mm or greater and its wall thickness about 10 mm or greater. When determining the RCP properties of a pipe in connection with the present invention, the outer diameter and the wall thickness have been selected to be 110 mm and 10 mm, respectively. While the exterior of the pipe is at ambient pressure (atmospheric pressure), the pipe is pressurised internally, and the internal pressure in the pipe is kept constant at a pressure of 0.5 MPa positive pressure. The pipe and the equipment surrounding it are thermostatted to a predetermined temperature. A number of discs have been mounted on a shaft inside the pipe to prevent decompression during the tests. A knife projectile is shot, with well-defined forms, towards the pipe close to its one end in the so-called initiating zone in order to start a rapidly running axial crack. The initiating zone is provided with an abutment for avoiding unnecessary deformation of the pipe. The test equipment is adjusted in such a manner that crack initiation takes place in the material involved, and a number of tests are effected at varying temperatures. The axial crack length in the measuring zone, having a total length of 4.5 diameters, is measured for each test and is plotted against the set test temperature. If the crack length exceeds 4 diameters, the crack is assessed to propagate. If the pipe passes the test at a given temperature, the temperature is lowered

successively until a temperature is reached, at which the pipe no longer passes the test, but the crack propagation exceeds 4 times the pipe diameter. The critical temperature (T_{crit}) i.e. the ductile brittle transition temperature as measured according to ISO DIS 13477 is the lowest temperature at which the pipe passes the test. The lower the critical temperature the better, since it results in an extension of the applicability of the pipe. It is desirable for the critical temperature to be around -5°C or lower. A pressure pipe made of the multimodal polymer composition according to the present invention preferably has an RCP-S4 value of -1°C (minimum requirement for an MD PE80 pipe) or lower, more preferably -4°C (minimum requirement for an HD PE80 pipe) or lower, and most preferably -7°C (minimum requirement for an HD PE100 pipe) or lower.

The design stress rating is the circumferential stress a pipe is designed to withstand for 50 years without failure and is determined for different temperatures in terms of the Minimum Required Strength (MRS) according to ISO/TR 9080. Thus, MRS8.0 means that the pipe is a pipe withstanding an internal pressure of 8.0 MPa gauge for 50 years at 20°C, and similarly MRS10.0 means that the pipe withstands an internal pressure of 10 MPa gauge for 50 years at 20°C. A pressure pipe made of the multimodal polymer composition according to the present invention preferably has a design stress rating of at least MRS8.0, and most preferably MRS10.0.

The impact strength is determined as Charpy Impact Strength according to ISO 179. A pressure pipe made of the multimodal polymer composition according to the present invention preferably has an impact resistance at 0°C of at least 10 kJ/m^2, more preferably at least 14 kJ/m^2, and most preferably at least 15 kJ/m^2.

The slow crack propagation resistance is determined according to ISO 13479:1997 in terms of the number of hours the pipe withstands a certain pressure at a certain

temperature before failure. A pressure pipe made of the multimodal polymer composition according to the present invention preferably has a slow crack propagation resistance of at least 1000 hrs at 4.0 MPa/80°C, and more preferably at least 500 hrs at 4.6 MPa/80°C.

The modulus of elasticity is determined according to ISO 527-2/1B. A pressure pipe made of the multimodal polymer composition according to the present invention preferably has a modulus of elasticity of at least 800 MPa, more preferably at least 950 MPa, and most preferably at least 1100 MPa.

A pressure pipe made of the multimodal polymer composition of the present invention is prepared in a conventional manner, preferably by extrusion in an extruder. This is a technique well known to the skilled person an no further particulars should therefore be necessary here concerning this aspect.

It is previously known to produce multimodal, in particular bimodal, olefin polymers, such as multimodal polyethylene, in two or more reactors connected in series. As instance of this prior art, mention may be made of EP 517 868, which is hereby incorporated by way of reference as regards the production of multimodal polymers.

According to the present invention, the main polymerisation stages are preferably carried out as a combination of slurry polymerisation/gas-phase polymerisation. The slurry polymerisation is preferably performed in a so-called loop reactor. The use of slurry polymerisation in a stirred-tank reactor is not preferred in the present invention, since such a method is not sufficiently flexible for the production of the inventive composition and involves solubility problems. In order to produce the inventive composition of improved properties, a flexible method is required. For this reason, it is preferred that the composition is produced in two main polymerisation stages in a combination of loop reactor/gas-phase reactor. Optionally and advantageously, the main polymerisation

stages may be preceded by a prepolymerisation, in which case up to 20% by weight, preferably 1-10% by weight, more preferably 1-5% by weight, of the total amount of polymers is produced. The prepolymer is preferably an ethylene homopolymer (HDPE). At the prepolymerisation all of the catalyst is preferably charged into a loop reactor and the prepolymerisation is performed as a slurry polymerisation. Such a prepolymerisation leads to less fine particles being produced in the following reactors and to a more homogeneous product being obtained in the end. Generally, this technique results in a multimodal polymer mixture through polymerisation with the aid of a Ziegler-Natta or metallocene catalyst in several successive polymerisation reactors. Chromium catalysts are not preferred in connection with the present invention because of the high degree of unsaturation they confer to the polymer. In the production of, say, a bimodal polyethylene, which according to the invention is the preferred polymer, a first ethylene polymer is produced in a first reactor under certain conditions with respect to hydrogen-gas pressure, temperature, pressure, and so forth. After the polymerisation in the first reactor, the reaction mixture including the polymer produced is fed to a second reactor, where further polymerisation takes place under other conditions. Usually, a first polymer of high melt flow rate (low molecular weight, LMW) and with no addition of comonomer is produced in the first reactor, whereas a second polymer of low melt flow rate (high molecular weight, HMW) and with addition of comonomer is produced in the second reactor. As comonomer of the HMW fraction various alpha-olefins with 4-8 carbon atoms may be used, but the comonomer is preferably selected from the group consisting of 1-butene, 1-hexene, 4-methyl-1-pentene, and 1-octene. The amount of comonomer is preferably such that it comprises 0.4-3.5 mol%, more preferably 0.7-2.5 mol% of the multimodal polyethylene. The resulting end product consists of an intimate mixture of the polymers from the

two reactors, the different molecular-weight-distribution curves of these polymers together forming a molecular--weight-distribution curve having a broad maximum or two maxima, i.e. the end product is a bimodal polymer mixture. Since multimodal, and especially bimodal, ethylene polymers, and the production thereof belong to the prior art, no detailed description is called for here, but reference is had to the above mentioned EP 517 868.

As hinted above, it is preferred that the multimodal polyethylene composition according to the invention is a bimodal polymer mixture. It is also preferred that this bimodal polymer mixture has been produced by polymerisation as above under different polymerisation conditions in two or more polymerisation reactors connected in series. Owing to the flexibility with respect to reaction conditions thus obtained, it is most preferred that the polymerisation is carried out in a loop reactor/a gas-phase reactor. Preferably, the polymerisation conditions in the preferred two-stage method are so chosen that a comparatively low-molecular polymer having no content of comonomer is produced in one stage, preferably the first stage, owing to a high content of chain-transfer agent (hydrogen gas), whereas a high-molecular polymer having a content of comonomer is produced in another stage, preferably the second stage. The order of these stages may, however, be reversed.

In the preferred embodiment of the polymerisation in a loop reactor followed by a gas-phase reactor, the polymerisation temperature in the loop reactor preferably is 92-98°C, more preferably about 95°C, and the temperature in the gas-phase reactor preferably is 75-90°C, more preferably 80-85°C.

A chain-transfer agent, preferably hydrogen, is added as required to the reactors, and preferably 350-450 moles of H_2/kmoles of ethylene are added to the reactor producing the LMW fraction and 20-40 moles of

H_2/kmoles of ethylene are added to the reactor producing the HMW fraction.

As indicated earlier, the catalyst for polymerising the multimodal polyethylene of the invention preferably is a Ziegler-Natta type catalyst. Particularly preferred are catalysts with a high overall activity as well as a good activity balance over a wide range of hydrogen partial pressures. As an example hereof may be mentioned the catalysts disclosed in EP 688794 and in FI 980788. Such catalysts also have the advantage that the catalyst (procatalyst and cocatalyst) only needs to and, indeed, only should be added in the first polymerisation reactor.

Although the invention has been described above with reference to a specified multimodal polyethylene, it should be understood that this multimodal polyethylene may include various additives such as fillers, etc. as is known and conventional in the art. Further, the pipe made of the specified multimodal polyethylene may be a single-layer pipe or form part of a multilayer pipe including further layers of other pipe materials.

Having thus described the present invention it will now be illustrated by way of non-limiting examples of preferred embodiments in order to further facilitate the understanding of the invention.

Example 1

A pipe resin was produced by means of a three-step process in a prepolymerisation loop-reactor followed by first a loop-reactor and then a gas phase-reactor. The split was 2:42:56. No comonomer was used in the two consecutive loop-reactors, while 1-butene was used as comonomer in the HMW-fraction produced in the gas phase-reactor in an amount such that the 1-butene comonomer content of the total resulting polymer was 2.6% by weight. A Ziegler-Natta type catalyst as disclosed in EP 688 794 was used. The M_n of the final polymer was found to be 8500 and the M_w 200000. M_w/M_n thus was 23.5. The density was 941 kg/m^3 (ISO 1183 D) and MFR_5 was

0.85 g/10 min. (ISO 1133, condition T). The processability was measured using a Battenfeldt 1-90-30B extruder, which gave an output of 730 kg/h at a screw speed of 158 rpm. The extruder head temperature was 220°C and the die temperature was 210°C. Under the same conditions a conventional unimodal polyethylene pipe resin (MDPE with a density of 940 kg/m^3 and an MFR_5 of 0,85 g/10 min) gave an output of 690 kg/h.

Physical test values were as follows:

E-modulus (ISO 527-2/1B)	840 MPa
Impact strength at 0°C (ISO 179)	16 kJ/m^2
Pressure test on unnotched	
32 mm pipe (ISO 1167)	>5000 h at 10.0 MPa/20°C
	>1000 h at 4.6 MPa/80°C
	>5000 h at 4.0 MPa/80°C
Pressure test on notched	
110 mm pipe (ISO 13479)	>5000 h at 4.0 MPa/80°C
RCP-resistance in the	
S4-test on 110 mm pipe	T_{crit} = -4°C

Exempel 2

A pipe resin was produced using the same reactor configuration as used in example 1. The split was 1:45:54. No comonomer was used in the two consecutive loop reactors, while 1-butene was used in the HMW-fraction produced in the gas phase reactor in an amount such that the 1-butene comonomer content of the total resulting polymer was 1.3% by weight. The same catalyst type was used as in example 1. The M_n of the final polymer was found to be 10500 and the M_w 285000. M_w/M_n thus was 27. The density was 959 kg/m^3 and MFR_5 was 0,35 g/10 min.

Physical test values were as follows:

E-modulus (ISO 527-2/1B)	1135 MPa
Impact strength at 0°C (ISO 179)	13.7 kJ/m^2
Pressure test on unnotched	
110 mm pipe (ISO 1167)	594 h at 12.4 MPa/20°C
	>10000 h at 5.0 MPa/80°C

Pressure test on notched 110 mm pipe (ISO 13479)	1500 h at 4.6 MPa/80°C
RCP-resistance in the S4-test on 110 mm pipe	T_{crit} = -7°C; P_{crit} >10 bar

CLAIMS

1. A multimodal polyethylene composition for pipes, which multimodal polyethylene has a density of 0.930-0.965 g/cm^3 and an MFR_5 of 0.2-1.2 g/10 min, characterised in that the multimodal polyethylene has an M_n of 8000-15000, an M_w of 180-330 x 10^3, and an M_w/M_n of 20-35, said multimodal polyethylene comprising a low molecular weight (LMW) ethylene homopolymer fraction and a high molecular weight (HMW) ethylene copolymer fraction, said HMW fraction having a lower molecular weight limit of 3500, and a weight ratio of the LMW fraction to the HMW fraction of (35-55):(65-45).

2. A multimodal polymer composition as claimed in claim 1, wherein the multimodal polymer is a bimodal polyethylene produced by (co)polymerisation in at least two steps.

3. A multimodal polymer composition as claimed in claim 1, wherein the ethylene copolymer of the HMW fraction is a copolymer of ethylene and a comonomer selected from the group consisting of 1-butene, 1-hexene, 4-methyl-1-pentene, and 1-octene.

4. A multimodal polymer composition as claimed in any one of claims 1-3, wherein the amount of comonomer is 0.4-3.5 mol% of the multimodal polymer.

5. A multimodal polymer composition according to any of claims 1-4, having a weight ratio of the LMW fraction to the HMW fraction of (43-51):(57-49).

6. A multimodal polymer composition as claimed in any one of claims 1-5, wherein the multimodal polymer has an MFR_5 of 0.3-1.0 g/10 min.

7. A multimodal polymer composition as claimed in claim 1, wherein the polymer is obtained by slurry polymerisation in a loop reactor of a LMW ethylene homo-

polymer fraction, followed by gas-phase polymerisation of a HMW ethylene copolymer fraction.

8. A multimodal polymer composition as claimed in claim 7, wherein the slurry polymerisation is preceded by a prepolymerisation step.

9. A multimodal polymer composition as claimed in claim 8, wherein the polymer is obtained by prepolymerisation in a loop reactor, followed by slurry polymerisation in a loop reactor of a LMW ethylene homopolymer fraction, and gas-phase polymerisation of a HMW ethylene copolymer fraction.

10. A multimodal polymer composition as claimed in any one of claims 7-9, wherein polymerisation procatalyst and cocatalyst are added to the first polymerisation reactor only.

11. A multimodal polymer composition as claimed in claim 10, wherein the polymerisation catalyst is a Ziegler-Natta type catalyst.

12. A pipe c h a r a c t e r i s e d in that it is a pressure pipe comprising the multimodal polymer composition according to any one of the preceding claims, which pipe withstands a pressure of 8.0 MPa gauge during 50 years at 20°C (MRS8.0).

13. A pipe as claimed in claim 12, wherein the pipe is a pressure pipe withstanding a pressure of 10 MPa gauge during 50 years at 20°C (MRS10.0).

14. A pipe as claimed in claim 12 or 13, wherein the pipe has a rapid crack propagation (RCP) S4-value of -1°C or lower.

15. A pipe as claimed in claim 14, wherein the pipe has a rapid crack propagation (RCP) S4-value of -7°C or lower.

ABSTRACT

A multimodal polymer composition for pipes is disclosed. The polymer is a multimodal polyethylene with a density of 0.930-0.965 g/cm^3, an MFR_5 of 0.2-1.2 g/10 min, an M_n of 8000-15000, an M_w of 180-330 x 10^3, and an M_w/M_n of 20-35, said multimodal polyethylene comprising a low molecular weight (LMW) ethylene homopolymer fraction and a high molecular weight (HMW) ethylene copolymer fraction, said HMW fraction having a lower molecular weight limit of 3500, and a weight ratio of the LMW fraction to the HMW fraction of (35-55):(65:45).

For Utility, PCT, and Design Applications

INSTRUCTIONS

Merchant & Gould
United States Patent Application
COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert TITLE of invention

POLYMER COMPOSITION FOR PIPES

Check a or b

The specification of which

a. ☒ is attached hereto

b. ☐ was filed on _____

If "b" checked, complete

as application serial no. _____

and was amended on _____ (if applicable)

If PCT Application

(in the case of PCT-filed application)

Insert Int. application number & filing date

described and claimed in international no. _____ filed _____

and as amended on _____ (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a). (Reprinted on back side).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent of inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

Prior applications Check a or b

a. ☐ no such applications havebeen filed.

b. ☒ such applications have been filed as follows:

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)
Sweden	9802409-4	6 July 1998	
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)

If "b" checked, complete

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

For Continuation-in-Part (CIP) Applications, complete

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)
PCT/SE99/01195	1 July 1999	pending

Revised 04/12/00

For Utility, PCT, and Design Applications

INSTRUCTIONS

Merchant & Gould
United States Patent Application
COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert TITLE of invention

POLYMER COMPOSITION FOR PIPES

Check a or b

The specification of which

a. ☒ is attached hereto

b. ☐ was filed on _____

If "b" checked, complete

as application serial no. _____

and was amended on _____ (if applicable)

If PCT Application

(in the case of PCT-filed application)

Insert Int. application number & filing date

described and claimed in international no. _____ filed _____

and as amended on _____ (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a). (Reprinted on back side).

I hereby claim foreign priority benefits under Title 35, United States Code, §119/365 of any foreign application(s) for patent of inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

Prior applications Check a or b

a. ☐ no such applications havebeen filed.

b. ☒ such applications have been filed as follows:

If "b" checked, complete

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)
Sweden	9802409-4	6 July 1998	
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code§ 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations§ 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

For Continuation-in-Part (CIP) Applications, complete

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)
PCT/SE99/01195	1 July 1999	pending

Revised 04/12/00

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Albrecht, John W.	Reg. No. 40,481	Gregson, Richard	Reg. No. 41,804	Qualey, Terry	Reg. No. 25,148
Anderson, Gregg I.	Reg. No. 28,828	Gresens, John J.	Reg. No. 33,112	Reich, John C.	Reg. No. 37,703
Batzli, Brian H.	Reg. No. 32,960	Hamre, Curtis B.	Reg. No. 29,165	Reiland, Earl D.	Reg. No. 25,767
Beard, John L.	Reg. No. 27,612	Hillson, Randall A.	Reg. No. 31,838	Schmaltz, David G.	Reg. No. 39,828
Berns, John M.	Reg. No. 43,496	Holzer, Jr., Richard J.	Reg. No. 42,668	Schuman, Mark D.	Reg. No. 31,197
Black, Bruce E.	Reg. No. 41,622	Johnston, Scott W.	Reg No. 39,721	Schumann, Michael D.	Reg. No. 30,422
Branch, John W.	Reg. No. 41,633	Kadievitch, Natalie D.	Reg. No. 34,196	Scull, Timothy B.	Reg. No. 42,137
Bremer, Dennis C.	Reg. No. 40,528	Karjeker, Shaukat	Reg. No. 34,049	Sebald, Gregory A.	Reg. No. 33,280
Bruess, Steven C.	Reg. No. 34,130	Kastelic, Joseph M.	Reg. No. 37,160	Skoog, Mark T.	Reg. No. 40,178
Byrne, Linda M.	Reg. No. 32,404	Kettelberger, Denise	Reg. No. 33,924	Spellman, Steven J.	Reg. No. 45,124
Carlson, Alan G.	Reg. No. 25,959	Keys, Jeramie J.	Reg. No. 42,724	Stoll-DeBell, Kirsten L.	Reg. No. 43,164
Caspers, Philip P.	Reg. No. 33,227	Knearl, Homer L.	Reg. No. 21,197	Storer, Shelley D.	Reg. No. 45,135
Chiapetta, James R.	Reg. No. 39,634	Kowalchyk, Alan W.	Reg. No. 31,535	Sumner, John P.	Reg. No. 29,114
Clifford, John A.	Reg. No. 30,247	Kowalchyk, Katherine M.	Reg. No. 36,848	Swenson, Erik G.	Reg. No. 45,147
Cochran, William W.	Reg. No. 26,652	Lacy, Paul A.	Reg. No. 38,946	Tellekson, David K.	Reg. No. 32,314
Daignault, Ronald A.	Reg. No. 25,968	Larson, James A.	Reg. No. 40,443	Trembath, Jon R.	Reg. No. 38,344
Daley, Dennis R.	Reg. No. 34,994	Liepa, Mara E.	Reg. No. 40,066	Underhill, Albert L.	Reg. No. 27,403
Dalglish, Leslie E.	Reg. No. 40,579	Lindquist, Timothy A.	Reg. No. 40,701	Vandenburgh, J. Derek	Reg. No. 32,179
Daulton, Julie R.	Reg. No. 36,414	Lycke, Lawrence E.	Reg. No. 38,540	Wahl, John R.	Reg. No. 33,044
DeVries Smith, Kate	Reg. No. 42,157	McAuley, Steven A.	Reg. No. P-46,084	Weaver, Karrie G.	Reg. No. 43,245
DiPietro, Mark J.	Reg. No. 28,707	McDonald, Daniel W.	Reg. No. 32,044	Welter, Paul A.	Reg. No. 20,890
Edell, Robert T.	Reg. No. 20,187	McIntyre, Jr. William F.	Reg. No. P-44,921	Whipps, Brian	Reg. No. 43,261
Epp Ryan, Sandra	Reg. No. 39,667	Mueller, Douglas P.	Reg. No. 30,300	Wickhem, J. Scot	Reg. No. 41,376
Glance, Robert J.	Reg. No. 40,620	Pauly, Daniel M.	Reg. No. 40,123	Williams, Douglas J.	Reg. No. 27,054
Goggin, Matthew J.	Reg. No. 44,125	Phillips, John B.	Reg. No. 37,206	Witt, Jonelle	Reg. No. 41,980
Golla, Charles E.	Reg. No. 26,896	Plunkett, Theodore	Reg. No. 37,209	Wu, Tong	Reg. No. 43,361
Gorman, Alan G.	Reg. No. 38,472	Prendergast, Paul	Reg. No. 46,068	Xu, Min S.	Reg. No. 39,536
Gould, John D.	Reg. No. 18,223	Pytel, Melissa J.	Reg. No. 37,209	Zeuli, Anthony R.	Reg. No. 45,255

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould to the contrary.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below (or if no address is specified, the first address):

☒ P.O. Box 2903; Minneapolis, MN 55402-0903 (Telephone No. (612) 332-5300)

☐ Independence Plaza, Suite 1400; 1050 17th St.; Denver, CO 80265-0100(Telephone No. (303) 357-1670)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Insert FULL name(s) AND address(es) of actual inventor(s)

2	FULL NAME OF INVENTOR	FAMILY NAME: ASUMALAHTI	FIRST GIVEN NAME: Markku	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: Kerava FIN	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
1	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Louhenkuja 3	CITY: KERAVA	STATE & ZIP CODE/COUNTRY: 04230 FINLAND
2	FULL NAME OF INVENTOR	FAMILY NAME: ÄÄRILÄÄ	FIRST GIVEN NAME: Jari	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: Porvoo	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
2	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Partiomiehentie 1B 31	CITY: PORVOO	STATE & ZIP CODE/COUNTRY: 06100 FINLAND
2	FULL NAME OF INVENTOR	FAMILY NAME: PALMROOS	FIRST GIVEN NAME: Ari	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: PORVOO	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
3	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Annantie 11	CITY: PORVOO	STATE & ZIP CODE/COUNTRY: 06400 FINLAND

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
	On separate Declaration	On separate Declaration
DATE: December 12, 2000	DATE	DATE

Each inventor must sign & date

Note: No legalization or other witness required

Revised 04/12/00

For Additional Inventors: ☒ Check box and attach sheet with same information, including date and signature.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Albrecht, John W.	Reg. No. 40,481	Gregson, Richard	Reg. No. 41,804	Qualey, Terry	Reg. No. 25,148
Anderson, Gregg I.	Reg. No. 28,828	Gresens, John J.	Reg. No. 33,112	Reich, John C.	Reg. No. 37,703
Batzli, Brian H.	Reg. No. 32,960	Hamre, Curtis B.	Reg. No. 29,165	Reiland, Earl D.	Reg. No. 25,767
Beard, John L.	Reg. No. 27,612	Hillson, Randall A.	Reg. No. 31,838	Schmaltz, David G.	Reg. No. 39,828
Berns, John M.	Reg. No. 43,496	Holzer, Jr., Richard J.	Reg. No. 42,668	Schuman, Mark D.	Reg. No. 31,197
Black, Bruce E.	Reg. No. 41,622	Johnston, Scott W.	Reg No. 39,721	Schumann, Michael D.	Reg. No. 30,422
Branch, John W.	Reg. No. 41,633	Kadievitch, Natalie D.	Reg. No. 34,196	Scull, Timothy B.	Reg. No. 42,137
Bremer, Dennis C.	Reg. No. 40,528	Karjeker, Shaukat	Reg. No. 34,049	Sebald, Gregory A.	Reg. No. 33,280
Bruess, Steven C.	Reg. No. 34,130	Kastelic, Joseph M.	Reg. No. 37,160	Skoog, Mark T.	Reg. No. 40,178
Byrne, Linda M.	Reg. No. 32,404	Kettelberger, Denise	Reg No. 33,924	Spellman, Steven J.	Reg. No. 45,124
Carlson, Alan G.	Reg. No. 25,959	Keys, Jeramie J.	Reg. No. 42,724	Stoll-DeBell, Kirsten L.	Reg. No. 43,164
Caspers, Philip P.	Reg. No. 33,227	Knearl, Homer L.	Reg. No. 21,197	Storer, Shelley D.	Reg. No. 45,135
Chiapetta, James R.	Reg. No. 39,634	Kowalchyk, Alan W.	Reg. No. 31,535	Sumner, John P.	Reg. No. 29,114
Clifford, John A.	Reg. No. 30,247	Kowalchyk, Katherine M.	Reg. No. 36,848	Swenson, Erik G.	Reg. No. 45,147
Cochran, William W.	Reg. No. 26,652	Lacy, Paul A.	Reg. No. 38,946	Tellekson, David K.	Reg. No. 32,314
Daignault, Ronald A.	Reg. No. 25,968	Larson, James A.	Reg. No. 40,443	Trembath, Jon R.	Reg. No. 38,344
Daley, Dennis R.	Reg. No. 34,994	Liepa, Mara E.	Reg. No. 40,066	Underhill, Albert L.	Reg. No. 27,403
Dalglish, Leslie E.	Reg. No. 40,579	Lindquist, Timothy A.	Reg. No. 40,701	Vandenburgh, J. Derek	Reg. No. 32,179
Daulton, Julie R.	Reg. No. 36,414	Lycke, Lawrence E.	Reg. No. 38,540	Wahl, John R.	Reg. No. 33,044
DeVries Smith, Kate	Reg. No. 42,157	McAuley, Steven A.	Reg. No. P-46,084	Weaver, Karrie G.	Reg. No. 43,245
DiPietro, Mark J.	Reg. No. 28,707	McDonald, Daniel W.	Reg. No. 32,044	Welter, Paul A.	Reg. No. 20,890
Edell, Robert T.	Reg. No. 20,187	McIntyre, Jr. William F.	Reg. No. P-44,921	Whipps, Brian	Reg. No. 43,261
Epp Ryan, Sandra	Reg. No. 39,667	Mueller, Douglas P.	Reg. No. 30,300	Wickhem, J. Scot	Reg. No. 41,376
Glance, Robert J.	Reg. No. 40,620	Pauly, Daniel M.	Reg. No. 40,123	Williams, Douglas J.	Reg. No. 27,054
Goggin, Matthew J.	Reg. No. 44,125	Phillips, John B.	Reg. No. 37,206	Witt, Jonelle	Reg. No. 41,980
Golla, Charles E.	Reg. No. 26,896	Plunkett, Theodore	Reg. No. 37,209	Wu, Tong	Reg. No. 43,361
Gorman, Alan G.	Reg. No. 38,472	Prendergast, Paul	Reg. No. 46,068	Xu, Min S.	Reg. No. 39,536
Gould, John D.	Reg. No. 18,223	Pytel, Melissa J.	Reg. No. 37,209	Zeuli, Anthony R.	Reg. No. 45,255

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould to the contrary.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below (or if no address is specified, the first address):

☒ P.O. Box 2903; Minneapolis, MN 55402-0903 (Telephone No. (612) 332-5300)

☐ Independence Plaza, Suite 1400; 1050 17th St.; Denver, CO 80265-0100(Telephone No. (303) 357-1670)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Insert FULL name(s) AND address(es) of actual inventor(s)

201	FULL NAME OF INVENTOR	FAMILY NAME: ASUMALAHTI	FIRST GIVEN NAME: Markku	SECOND GIVEN NAME:
	RESIDENCE & CITIZENSHIP	CITY: Kerava	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Louhenkuja 3	CITY: KERAVA	STATE & ZIP CODE/COUNTRY: 04230 FINLAND
202	FULL NAME OF INVENTOR	FAMILY NAME: ÄÄRILÄÄ	FIRST GIVEN NAME: Jari	SECOND GIVEN NAME:
	RESIDENCE & CITIZENSHIP	CITY: Porvoo FIX	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Partiomiehentie 1B 31	CITY: PORVOO	STATE & ZIP CODE/COUNTRY: 06100 FINLAND
203	FULL NAME OF INVENTOR	FAMILY NAME: PALMROOS	FIRST GIVEN NAME: Ari	SECOND GIVEN NAME:
	RESIDENCE & CITIZENSHIP	CITY: Porvoo	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Annantie 11	CITY: PORVOO	STATE & ZIP CODE/COUNTRY: 06400 FINLAND

Each inventor must sign & date

Note: No legalization or other witness required

Revised 04/12/00

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
On separate Declaration		On separate Declaration
DATE	DATE December 7, 2000	DATE

For Additional Inventors: ☒ Check box and attach sheet with same information, including date and signature.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Albrecht, John W.	Reg. No. 40,481	Gregson, Richard	Reg. No. 41,804	Qualey, Terry	Reg. No. 25,148
Anderson, Gregg I.	Reg. No. 28,828	Gresens, John J.	Reg. No. 33,112	Reich, John C.	Reg. No. 37,703
Batzli, Brian H.	Reg. No. 32,960	Hamre, Curtis B.	Reg. No. 29,165	Reiland, Earl D.	Reg. No. 25,767
Beard, John L.	Reg. No. 27,612	Hillson, Randall A.	Reg. No. 31,838	Schmaltz, David G.	Reg. No. 39,828
Berns, John M.	Reg. No. 43,496	Holzer, Jr., Richard J.	Reg. No. 42,668	Schuman, Mark D.	Reg. No. 31,197
Black, Bruce E.	Reg. No. 41,622	Johnston, Scott W.	Reg No. 39,721	Schumann, Michael D.	Reg. No. 30,422
Branch, John W.	Reg. No. 41,633	Kadievitch, Natalie D.	Reg. No. 34,196	Scull, Timothy B.	Reg. No. 42,137
Bremer, Dennis C.	Reg. No. 40,528	Karjeker, Shaukat	Reg. No. 34,049	Sebald, Gregory A.	Reg. No. 33,280
Bruess, Steven C.	Reg. No. 34,130	Kastelic, Joseph M.	Reg. No. 37,160	Skoog, Mark T.	Reg. No. 40,178
Byrne, Linda M.	Reg. No. 32,404	Kettelberger, Denise	Reg. No. 33,924	Spellman, Steven J.	Reg. No. 45,124
Carlson, Alan G.	Reg. No. 25,959	Keys, Jeramie J.	Reg. No. 42,724	Stoll-DeBell, Kirsten L.	Reg. No. 43,164
Caspers, Philip P.	Reg. No. 33,227	Knearl, Homer L.	Reg. No. 21,197	Storer, Shelley D.	Reg. No. 45,135
Chiapetta, James R.	Reg. No. 39,634	Kowalchyk, Alan W.	Reg. No. 31,535	Sumner, John P.	Reg. No. 29,114
Clifford, John A.	Reg. No. 30,247	Kowalchyk, Katherine M.	Reg. No. 36,848	Swenson, Erik G.	Reg. No. 45,147
Cochran, William W.	Reg. No. 26,652	Lacy, Paul A.	Reg. No. 38,946	Tellekson, David K.	Reg. No. 32,314
Daignault, Ronald A.	Reg. No. 25,968	Larson, James A.	Reg. No. 40,443	Trembath, Jon R.	Reg. No. 38,344
Daley, Dennis R.	Reg. No. 34,994	Liepa, Mara E.	Reg. No. 40,066	Underhill, Albert L.	Reg. No. 27,403
Dalglish, Leslie E.	Reg. No. 40,579	Lindquist, Timothy A.	Reg. No. 40,701	Vandenburgh, J. Derek	Reg. No. 32,179
Daulton, Julie R.	Reg. No. 36,414	Lycke, Lawrence E.	Reg. No. 38,540	Wahl, John R.	Reg. No. 33,044
DeVries Smith, Kate	Reg. No. 42,157	McAuley, Steven A.	Reg. No. P-46,084	Weaver, Karrie G.	Reg. No. 43,245
DiPietro, Mark J.	Reg. No. 28,707	McDonald, Daniel W.	Reg. No. 32,044	Welter, Paul A.	Reg. No. 20,890
Edell, Robert T.	Reg. No. 20,187	McIntyre, Jr. William F.	Reg. No. P-44,921	Whipps, Brian	Reg. No. 43,261
Epp Ryan, Sandra	Reg. No. 39,667	Mueller, Douglas P.	Reg. No. 30,300	Wickhem, J. Scot	Reg. No. 41,376
Glance, Robert J.	Reg. No. 40,620	Pauly, Daniel M.	Reg. No. 40,123	Williams, Douglas J.	Reg. No. 27,054
Goggin, Matthew J.	Reg. No. 44,125	Phillips, John B.	Reg. No. 37,206	Witt, Jonelle	Reg. No. 41,980
Golla, Charles E.	Reg. No. 26,896	Plunkett, Theodore	Reg. No. 37,209	Wu, Tong	Reg. No. 43,361
Gorman, Alan G.	Reg. No. 38,472	Prendergast, Paul	Reg. No. 46,068	Xu, Min S.	Reg. No. 39,536
Gould, John D.	Reg. No. 18,223	Pytel, Melissa J.	Reg. No. 37,209	Zeuli, Anthony R.	Reg. No. 45,255

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould to the contrary.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below (or if no address is specified, the first address):

☒ P.O. Box 2903; Minneapolis, MN 55402-0903 (Telephone No. (612) 332-5300)

☐ Independence Plaza, Suite 1400; 1050 17th St.; Denver, CO 80265-0100(Telephone No. (303) 357-1670)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Insert FULL name(s) AND address(es) of actual inventor(s)

2	FULL NAME OF INVENTOR	FAMILY NAME: ASUMALAHTI	FIRST GIVEN NAME: Markku	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: Kerava	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
1	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Louhenkuja 3	CITY: KERAVA	STATE & ZIP CODE/COUNTRY: 04230 FINLAND
2	FULL NAME OF INVENTOR	FAMILY NAME: ÄÄRILÄÄ	FIRST GIVEN NAME: Jari	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: Porvoo	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
2	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Partiomiehentie 1B 31	CITY: PORVOO	STATE & ZIP CODE/COUNTRY: 06100 FINLAND
2	FULL NAME OF INVENTOR	FAMILY NAME: PALMROOS	FIRST GIVEN NAME: Ari	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: Porvoo FIX	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
3	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Annantie 11	CITY: PORVOO	STATE & ZIP CODE/COUNTRY: 06400 FINLAND

300

Each inventor must sign & date

Note: No legalization or other witness required

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
On separate Declaration	On separate Declaration	
DATE	DATE	DATE December 1, 2000

Revised 04/12/00

For Additional Inventors: ☒ Check box and attach sheet with same information, including date and signature.

200	FULL NAME OF INVENTOR	FAMILY NAME BÄCKMAN	FIRST GIVEN NAME Mats	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Göteborg SE	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Forsstenagatan 4 H	CITY GÖTEBORG	STATE & ZIP CODE/COUNTRY 416 51 SWEDEN
205	FULL NAME OF INVENTOR	FAMILY NAME NILSSON	FIRST GIVEN NAME Anette	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Stora Höga	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Hermans väg 11	CITY STORA HÖGA	STATE & ZIP CODE/COUNTRY 444 60 SWEDEN
206	FULL NAME OF INVENTOR	FAMILY NAME PALMLÖF	FIRST GIVEN NAME Magnus	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Västra Frölunda	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Nya Varvet 9	CITY VÄSTRA FRÖLUNDA	STATE & ZIP CODE/COUNTRY 426 71 SWEDEN

SIGNATURE OF INVENTOR 204 Mats Bäckman	SIGNATURE OF INVENTOR 205 On separate Declaration	SIGNATURE OF INVENTOR 206 On separate Declaration
DATE December 15, 2000	DATE	DATE

207	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
208	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
209	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

SIGNATURE OF INVENTOR 207	SIGNATURE OF INVENTOR 208	SIGNATURE OF INVENTOR 209
DATE	DATE	DATE

2	FULL NAME OF INVENTOR	FAMILY NAME BÄCKMAN	FIRST GIVEN NAME Mats	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY Göteborg	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
4	POST OFFICE ADDRESS	POST OFFICE ADDRESS Forsstenagatan 4 H	CITY GÖTEBORG	STATE & ZIP CODE/COUNTRY 416 51 SWEDEN
2	FULL NAME OF INVENTOR	FAMILY NAME NILSSON	FIRST GIVEN NAME Anette	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY Stora Höga SE	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
5	POST OFFICE ADDRESS	POST OFFICE ADDRESS Hermans väg 11	CITY STORA HÖGA	STATE & ZIP CODE/COUNTRY 444 60 SWEDEN
2	FULL NAME OF INVENTOR	FAMILY NAME PALMLÖF	FIRST GIVEN NAME Magnus	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY Västra Frölunda	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
6	POST OFFICE ADDRESS	POST OFFICE ADDRESS Nya Varvet 9	CITY VÄSTRA FRÖLUNDA	STATE & ZIP CODE/COUNTRY 426 71 SWEDEN

SIGNATURE OF INVENTOR 204 On separate Declaration	SIGNATURE OF INVENTOR 205 Anette Nilsson	SIGNATURE OF INVENTOR 206 On separate Declaration
DATE	DATE December 5, 2000	DATE

2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
7	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
8	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
9	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

SIGNATURE OF INVENTOR 207	SIGNATURE OF INVENTOR 208	SIGNATURE OF INVENTOR 209
DATE	DATE	DATE

202	FULL NAME OF INVENTOR	FAMILY NAME BÄCKMAN	FIRST GIVEN NAME Mats	SECOND GIVEN NAME
204	RESIDENCE & CITIZENSHIP	CITY Göteborg	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
206	POST OFFICE ADDRESS	POST OFFICE ADDRESS Forsstenagatan 4 H	CITY GÖTEBORG	STATE & ZIP CODE/COUNTRY 416 51 SWEDEN
202	FULL NAME OF INVENTOR	FAMILY NAME NILSSON	FIRST GIVEN NAME Anette	SECOND GIVEN NAME
204	RESIDENCE & CITIZENSHIP	CITY Stora Höga	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
205	POST OFFICE ADDRESS	POST OFFICE ADDRESS Hermans väg 11	CITY STORA HÖGA	STATE & ZIP CODE/COUNTRY 444 60 SWEDEN
202	FULL NAME OF INVENTOR	FAMILY NAME PALMLÖF	FIRST GIVEN NAME Magnus	SECOND GIVEN NAME
204	RESIDENCE & CITIZENSHIP	CITY Västra Frölunda SE	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
206	POST OFFICE ADDRESS	POST OFFICE ADDRESS Nya Varvet 9	CITY VÄSTRA FRÖLUNDA	STATE & ZIP CODE/COUNTRY 426 71 SWEDEN

SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
On separate Declaration	On separate Declaration	
DATE	DATE	DATE December 20, 2000

600

207	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
209	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
210	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
207	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
209	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
211	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
207	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
209	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
212	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

SIGNATURE OF INVENTOR 207	SIGNATURE OF INVENTOR 208	SIGNATURE OF INVENTOR 209
DATE	DATE	DATE

For Utility, PCT, and Design Applications

INSTRUCTIONS

Merchant & Gould

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert TITLE of invention

POLYMER COMPOSITION FOR PIPES

Check a or b

The specification of which

a. ☒ is attached hereto

b. ☐ was filed on _____

If "b" checked, complete

as application serial no. _____

and was amended on _____ (if applicable)

If PCT Application

(in the case of PCT-filed application)

Insert Int. application number & filing date

described and claimed in international no. _____ filed _____

and as amended on _____ (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a). (Reprinted on back side).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent of inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

Prior applications Check a or b

a. ☐ no such applications havebeen filed.

b. ☒ such applications have been filed as follows:

If "b" checked, complete

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)
Sweden	9802409-4	6 July 1998	
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

For Continuation-in-Part (CIP) Applications, complete

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)
PCT/SE99/01195	1 July 1999	pending

Revised 04/12/00

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Albrecht, John W.	Reg. No. 40,481	Gregson, Richard	Reg. No. 41,804	Qualey, Terry	Reg. No. 25,148
Anderson, Gregg I.	Reg. No. 28,828	Gresens, John J.	Reg. No. 33,112	Reich, John C.	Reg. No. 37,703
Batzli, Brian H.	Reg. No. 32,960	Hamre, Curtis B.	Reg. No. 29,165	Reiland, Earl D.	Reg. No. 25,767
Beard, John L.	Reg. No. 27,612	Hillson, Randall A.	Reg. No. 31,838	Schmaltz, David G.	Reg. No. 39,828
Berns, John M.	Reg. No. 43,496	Holzer, Jr., Richard J.	Reg. No. 42,668	Schuman, Mark D.	Reg. No. 31,197
Black, Bruce E.	Reg. No. 41,622	Johnston, Scott W.	Reg. No. 39,721	Schumann, Michael D.	Reg. No. 30,422
Branch, John W.	Reg. No. 41,633	Kadievitch, Natalie D.	Reg. No. 34,196	Scull, Timothy B.	Reg. No. 42,137
Bremer, Dennis C.	Reg. No. 40,528	Karjeker, Shaukat	Reg. No. 34,049	Sebald, Gregory A.	Reg. No. 33,280
Bruess, Steven C.	Reg. No. 34,130	Kastelic, Joseph M.	Reg. No. 37,160	Skoog, Mark T.	Reg. No. 40,178
Byrne, Linda M.	Reg. No. 32,404	Kettelberger, Denise	Reg. No. 33,924	Spellman, Steven J.	Reg. No. 45,124
Carlson, Alan G.	Reg. No. 25,959	Keys, Jeramie J.	Reg. No. 42,724	Stoll-DeBell, Kirsten L.	Reg. No. 43,164
Caspers, Philip P.	Reg. No. 33,227	Knearl, Homer L.	Reg. No. 21,197	Storer, Shelley D.	Reg. No. 45,135
Chiapetta, James R.	Reg. No. 39,634	Kowalchyk, Alan W.	Reg. No. 31,535	Sumner, John P.	Reg. No. 29,114
Clifford, John A.	Reg. No. 30,247	Kowalchyk, Katherine M.	Reg. No. 36,848	Swenson, Erik G.	Reg. No. 45,147
Cochran, William W.	Reg. No. 26,652	Lacy, Paul A.	Reg. No. 38,946	Tellekson, David K.	Reg. No. 32,314
Daignault, Ronald A.	Reg. No. 25,968	Larson, James A.	Reg. No. 40,443	Trembath, Jon R.	Reg. No. 38,344
Daley, Dennis R.	Reg. No. 34,994	Liepa, Mara E.	Reg. No. 40,066	Underhill, Albert L.	Reg. No. 27,403
Dalglish, Leslie E.	Reg. No. 40,579	Lindquist, Timothy A.	Reg. No. 40,701	Vandenburgh, J. Derek	Reg. No. 32,179
Daulton, Julie R.	Reg. No. 36,414	Lycke, Lawrence E.	Reg. No. 38,540	Wahl, John R.	Reg. No. 33,044
DeVries Smith, Kate	Reg. No. 42,157	McAuley, Steven A.	Reg. No. P-46,084	Weaver, Karrie G.	Reg. No. 43,245
DiPietro, Mark J.	Reg. No. 28,707	McDonald, Daniel W.	Reg. No. 32,044	Welter, Paul A.	Reg. No. 20,890
Edell, Robert T.	Reg. No. 20,187	McIntyre, Jr. William F.	Reg. No. P-44,921	Whipps, Brian	Reg. No. 43,261
Epp Ryan, Sandra	Reg. No. 39,667	Mueller, Douglas P.	Reg. No. 30,300	Wickhem, J. Scot	Reg. No. 41,376
Glance, Robert J.	Reg. No. 40,620	Pauly, Daniel M.	Reg. No. 40,123	Williams, Douglas J.	Reg. No. 27,054
Goggin, Matthew J.	Reg. No. 44,125	Phillips, John B.	Reg. No. 37,206	Witt, Jonelle	Reg. No. 41,980
Golla, Charles E.	Reg. No. 26,896	Plunkett, Theodore	Reg. No. 37,209	Wu, Tong	Reg. No. 43,361
Gorman, Alan G.	Reg. No. 38,472	Prendergast, Paul	Reg. No. 46,068	Xu, Min S.	Reg. No. 39,536
Gould, John D.	Reg. No. 18,223	Pytel, Melissa J.	Reg. No. 37,209	Zeuli, Anthony R.	Reg. No. 45,255

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould to the contrary.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below (or if no address is specified, the first address):

☒ P.O. Box 2903; Minneapolis, MN 55402-0903 (Telephone No. (612) 332-5300)

☐ Independence Plaza, Suite 1400; 1050 17th St.; Denver, CO 80265-0100(Telephone No. (303) 357-1670)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Insert FULL name(s) AND address(es) of actual inventor(s)

2	FULL NAME OF INVENTOR	FAMILY NAME: ASUMALAHTI	FIRST GIVEN NAME: Markku	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: Kerava	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
1	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Louhenkuja 3	CITY: KERAVA	STATE & ZIP CODE/COUNTRY: 04230 FINLAND
2	FULL NAME OF INVENTOR	FAMILY NAME: ÄÄRILÄÄ	FIRST GIVEN NAME: Jari	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: Porvoo	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
2	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Partiomiehentie 1B 31	CITY: PORVOO	STATE & ZIP CODE/COUNTRY: 06100 FINLAND
2	FULL NAME OF INVENTOR	FAMILY NAME: PALMROOS	FIRST GIVEN NAME: Ari	SECOND GIVEN NAME:
0	RESIDENCE & CITIZENSHIP	CITY: Porvoo	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
3	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Annantie 11	CITY: PORVOO	STATE & ZIP CODE/COUNTRY: 06400 FINLAND

Each inventor must sign & date

Note: No legalization or other witness required

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
On separate Declaration	On separate Declaration	On separate Declaration
DATE	DATE	DATE

Revised 04/12/00

For Additional Inventors: ☒ Check box and attach sheet with same information, including date and signature.

2	FULL NAME OF INVENTOR	FAMILY NAME BÄCKMAN	FIRST GIVEN NAME Mats	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY Göteborg	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
4	POST OFFICE ADDRESS	POST OFFICE ADDRESS Forsstenagatan 4 H	CITY GÖTEBORG	STATE & ZIP CODE/COUNTRY 416 51 SWEDEN
2	FULL NAME OF INVENTOR	FAMILY NAME NILSSON	FIRST GIVEN NAME Anette	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY Stora Höga	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
5	POST OFFICE ADDRESS	POST OFFICE ADDRESS Hermans väg 11	CITY STORA HÖGA	STATE & ZIP CODE/COUNTRY 444 60 SWEDEN
2	FULL NAME OF INVENTOR	FAMILY NAME PALMLÖF	FIRST GIVEN NAME Magnus	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY Västra Frölunda	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
6	POST OFFICE ADDRESS	POST OFFICE ADDRESS Nya Varvet 9	CITY VÄSTRA FRÖLUNDA	STATE & ZIP CODE/COUNTRY 426 71 SWEDEN

SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
On separate Declaration	On separate Declaration	On separate Declaration
DATE	DATE	DATE

2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
7	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
8	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
9	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

SIGNATURE OF INVENTOR 207	SIGNATURE OF INVENTOR 208	SIGNATURE OF INVENTOR 209
DATE	DATE	DATE

Revised 04/12/00

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentabilitywhen it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim;
or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application:

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.